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I, LEANNE MYNOTT, MANAGER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2003902319 for a patent by VISION FIRE AND SECURITY PTY LTD as filed on 14 May 2003.

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Regulation 3.2

Vision Fire and Security Pty Ltd

AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

for the invention entitled:

"Laser Video Detector"

The invention is described in the following statement:

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Laser Video Detector

The present invention relates to an improved sensor apparatus and improved method of sensing. In particular the present invention relates to an improved particle detector and method of detecting particles.

Detecting particles in a fluid, such as air, is useful in applications such as fire or smoke detection.

Video based systems have been usefully employed in the past to automatically recognize smoke and raise alarms. However, these systems have suffered from relatively poor sensitivity, inability to operate correctly in moving air and the need for adequate ambient lighting. These limitations are obviated in the present invention.

Figure 1 shows a schematic representation of a first embodiment of a detector;

Figure 2 shows a schematic representation of a second embodiment of the detector.

A sensing arrangement such as a detector system 10 includes a video camera 6 and a light source 1, situated within a volume such as a room. Detecting light 4 from the light source 1 is directed towards the camera 6, however in the embodiment in figure 1, the detecting light 4 does not directly impact on a lens 6.1 of the camera 6. Typically the light source 1 may be a solid state laser source, such as a laser diode, with a collimating lens 2. Other light sources may be used. Preferably the detecting light 4 is a monochromatic light of a known frequency.

The camera 6 may be a charge coupled device (CCD) type camera, which are inherently sensitive to infra-red light. That is, CCD devices are typically able to see not only light visible to the human eye, but also detect infra-red light not able to be seen by the human eye. The light entering the camera may be filtered with a filter 5 to reduce the visible light, allowing only for example, infrared light to pass. This is useful if the light source emits infrared light, by reducing background light. The filter 5 may constantly filter light, or, may only filter visible light during certain time periods. This would allow, for example, the camera to be used for other purposes such as security monitoring.

When light travels through a fluid containing particles, light hitting the particles causes scattering. The amount of scattered light increases as the number of particles in the fluid (such as air) increases. It is possible to estimate the level of particles in a body of air by measuring the level of scatter of light travelling through the body of air.

In figure 1, the light source 1 emits the detecting light through a collimating lens 2. In this embodiment a beam steerer 3 is used to enable the detecting light 4 to be directed to a number of locations, providing detection along a number of paths through the air. Particles 13, on being hit with the detecting light 4, produce scattered light 14, some of which is detected by the camera 6. The field of view of the camera is shown as θ. The signal from the camera 6 is fed into the video processing subsystem 7, which may be connected to the light source control system 7 via a communications link 8. The output of the video processing subsystem 7 is connected to a monitor 9 and a annunciating system 10, which may indicate an alarm if certain thresholds and conditions are met. In figure 1 the camera 6 detects forward scatter with the camera located a distance from the light source, and the detecting light 4 being absorbed by the light absorber 15. In figure 2, the camera 6 and the light source 1 are located together, and may be in the same housing. Detecting light from the light source 1 is directed to a reflector 16, and therefore passes through the air twice. This system reduces the installation cost in certain applications.

The camera 6 is located so as to be angled with respect to the light source 1 such that the image can beneficially reveal the location of a cloud of particles scattering light within the protected space. To provide improved resolution of the location of this cloud, purpose-designed optics, such as a non-symmetrical lens, may be employed to compensate for the smaller change of angle of view from points located distant from the camera.

In the present embodiment the camera 6 takes a series of frames of a volume of air through which the light passes. The images are transmitted to a video processing sub-system 7, where they are processed and stored in a storage device (not shown), such as a digital video recorder. Parts of the image not related to scattered light from

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particles may be removed to improve the resolution of the location of the scattered light.

In one embodiment, a modulation and synchronisation sub-system 12 is provided. The modulation sub-system modulates the amplitude of the light, for example in a series of pulses. When the light amplitude is modulated, various techniques may be used to synchronously detect the variable light output, thus increasing sensitivity of the detection of the scattered light. In one embodiment the modulation is synchronised with the frame capture rate of the camera. Thus the camera will see one image with the light source on and the next with the light source off (or multiples of frames on and off). The camera frame rate may be synchronous with the frequency of the alternating current mains supply (eg 50-60 Hz depending on location) and is preferably phase locked with the modulation of light output from the light source.

When the camera takes an image with the light source off, the processor counts the amount of light at the set frequency of the light source, and uses this as a reference background level. Processing of the image with the light source on can then remove the level of background light detected previously, and ascertain the level of scattering of light from the light source. Background light levels may be ascertained by a averaging the background light level over a number of frames where the detecting light is either off or modulated to its lowest level. This task is made easier if the light source is monochromatic, as filters may be used (hardware or electronic band-pass) to remove other frequencies of light. Preferably the modulation frequency used minimizes the nuisance light sources that will vary with time, such as fluorescent lights, which typically emit light in pulses timed to the mains frequency, although to the naked eye they appear to emit constant light. This may be achieved by using a camera which has a frame rate that can be phase locked to the mains supply frequency and by selecting a modulation frequency that is a sub-multiple of the ac mains supply. A signal derived from the ac mains supply may be used as a synchronisation reference.

The level of scattering is taken as a proxy for the number of particles in the air in the path of the light source. The processor can be programmed to accept a set level of

background scatter as an acceptable particle level for the body of air in a particular circumstance.

Each image is processed and the amount of detecting light at the over the background light is calculated, and becomes scattered light. If the level of scattered light detected exceeds a preset-threshold, then an alarm may be signalled.

The video-processing sub-system 7 performs an analysis of the stream of video image frames, using data 8 passed into and from the synchronisation sub-system 11 to extract a measure of the location, quantity and composition of the airborne particles 13. This information is compared to thresholds stored in the sub-system 7 and if exceeded, notification is passed to the alarm annunciating system 10. Various stages of alarm may be employed, in the earliest case the alarm may simply indicator to an operator that the event should be investigated. Preferably the video image passed to the monitor 9 has graphical enhancements shown in the location of the suspected smoke to assist the operator to determine the required action to take.

The camera could also have an automatic pan function, for example sweeping area. The amount of scattered light or background light could be varied according to camera position so that changes in camera view did not cause an alarm where there was no increase in particles in the air. The position and view of the camera will affect the amount of scattered light received. The camera may be positioned looking down at the light beam, or towards the light beam but positioned so that the light beam is not directly incident with the beam.

If a laser is used, then typically the amount of light received where the beam strikes a sensor is many times the amount received from scattered light. Therefore the detecting light should not be directly incident on the camera. The detecting light may actually be directed towards a camera but sufficient shielding would be required to ensure that sufficient scattered light could be detected to measure increases in particles in the air.

In another embodiment a camera may be mounted to a ceiling and view a room through a 360-degree lens. One or more lasers and/or reflectors may be used to illuminate different sections of the room.

The camera may be distant from the light source, such as the embodiment shown in figure 1. In such as case, the laser, camera and other systems may be directly linked to each other by wires, such as video or computer cable, infra-red links or other known means of transmitting video and control data.

Another means of detecting modulation is to analyse the pattern of variation in the received scattered light, and thereby ascertain the frequency of modulation of amplitude of the light source. This information can be used by the video processing sub-system when the frequency and characteristics of modulation are known. This methodology of calculating phase eliminates the necessity for a data connection between the light source (or controller therefore) and the video processing sub-system, which may be desirable in some circumstances.

In another embodiment, the laser and camera may be mounted together or near each other, with the laser aimed away from the camera. Optionally, a reflector may be mounted at a point distant from the camera and laser, to reflect the detecting light back at the laser. This embodiment allows scattered light to be detected as the laser moves away and toward the light source. Light moving towards the camera will produce more scattered light than light moving away from the camera, as the scattered light tends to be concentrated a few degrees from the beam. It is therefore better from a resolution perspective to have the camera looking toward the detecting light rather than following the detecting light as backscattering will be reduced.

The modulation of the light source may be done electronically by varying the power of the laser, or with a mechanical device such as a chopping wheel that physically interrupts the detecting light. Other means of varying the light may also be employed.

In another embodiment, the polarisation of the light source may change. This may be accomplished by using an inherently polarised light source, such as a laser diodes, or by use of a polarising filter. The polarization of the light may then be altered, for example by rotating the source (1) around the axis of the light beam through 90

degrees between readings. Comparison of the relative signal strengths then yields particle size information, as shown by Gravatt US patent 3901602. This is beneficial as it permits particles generated non-thermally, eg dust, to be distinguished from smoke to prevent false alarms.

In another embodiment, the frequency of the light source may change. This may be accomplished by varying the output of the light source, either electronically or by using a number of light sources, such as two or more laser diodes. Different frequencies of light offer advantages such as reduced interference from some background light, as well as enabling better resolution of particle size. Smaller particles reflect more light at smaller wavelengths than larger particles, therefore using more than one frequency of light it is possible to estimate the size distribution of the particles scattering the light. This may be important if certain the detector is attempting to detect particles of a certain size, or ignore particles of a certain size. For example, if the region where the detector is situated has variable levels of small particles of a known size, then fluctuations of these particle levels may be able to be safely ignored.

The modulation of multiple light sources may be done together or separately depending on the result required.

In figure 2 a detecting system 100 is shown, using a reflector to reflect the beam back towards the camera. If multiple light sources are used, then there may be a deflector for each light source, or a single deflector.

In figure 1 the light source may impinge on a light absorbent material or a light trap to reduce background scattering. The light source may produce a thin focussed beam, from for example a collimated laser diode. Alternatively the beam may be diffused for safety or other purposes. For example a collimating lens of longer focal length with could be used to broaden the beam. In terms of safety, a broader beam has a lower watt per mm2 intensity, and therefore poses less risk to persons who may look into the beam. Ideally, if safety were an issue, the light source would be directed away from areas likely to cause safety issues.

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It is desirable to use a laser light source of the lowest power practicable, for both cost and safety reasons. In most instances it is envisaged that the methods described to improve sensitivity will permit light sources to be used which conform to legislated requirements for eye safety. In cases where it might be desirable to use higher laser powers rapid shutdown of the light source may be made when the camera system perceives an object has entered the region of the beam, to obviate risk of eye-damage.

If the detected light is directed at a light absorbent material or light trap, such that little or no detected light is reflected from the location that the detecting light hits a surface, then additional features may be included. Such a feature involves detecting the amount of light reflected from the known location where the detecting light hits a surface. If an object crosses the beam, then the light reflected back to the camera will increase significantly. In such a case a detection system could detect the increased reflected light and turn of the light source. This is useful if, for example, people are in the area to be detected and the light source is considered a health issue. Processing of the camera signal would allow the system to detect the difference between scattered light, which will produce short lived pulses of light in random locations, from a relatively steady and long lived reflection of light from a solid object. Motion detection software may then be used to detect when the object is likely to have moved from the area where the light hits the surface.

The present embodiments may be used in areas such as rooms, hallways, factories or tunnels, and is especially useful where visual inspection is desirable as well as smoke detection. This system enables particle detection via a camera well before it would generally be possible to ascertain the presence of particles (for example smoke) by looking at the degradation of the image due to obscuration.

In another application, the system described above could be used in applications where measurement of obscuration was important, such as airports where fog may cause planes to divert if visibility falls below a certain level. The system does not require ambient light to operate, and can therefore operate at night without additional lighting. An infrared camera could also be used with an infrared light source, where

the light source, if of similar frequency to the detecting light, could be cycled so that the processor ignores frames illuminated for security purposes.

A typical security camera may take 25 images per second. Smoke detection may only require detection 1 per second or less. Therefore the remaining images can be used for security purposes.

To give increased sensitivity, video processing software operating within the detection sub-system (6,7) may be used to eliminate the contribution of nuisance changes in video signals which are not in the location known to be occupied by the light beam. Software based systems which perform a similar function of processing distinct areas of a video image are known, for example in video-based security systems such as Vision System's ADPRO products.

DATED this 14th day of May, 2003

Vision Fire and Security Pty Ltd

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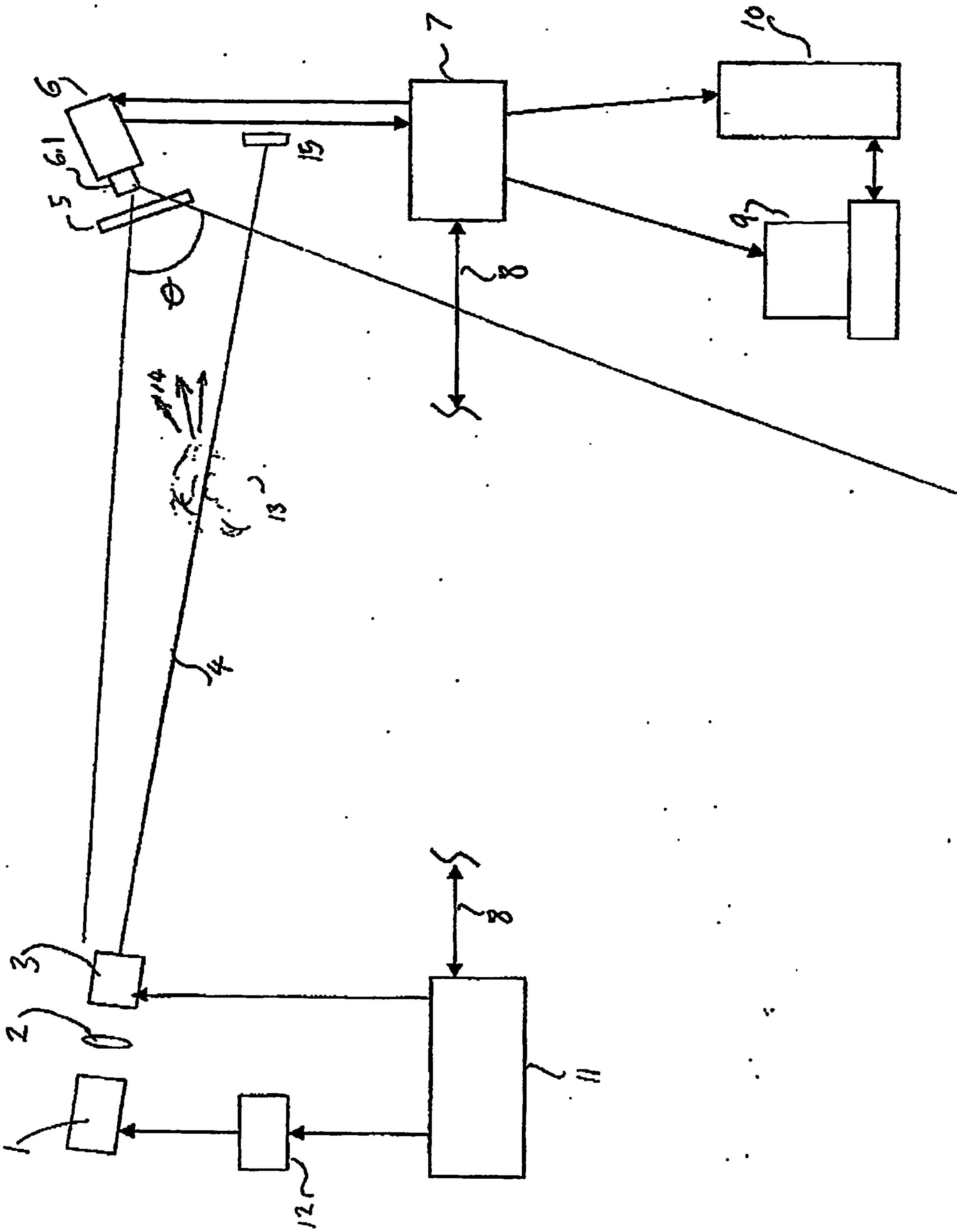

Fig 1

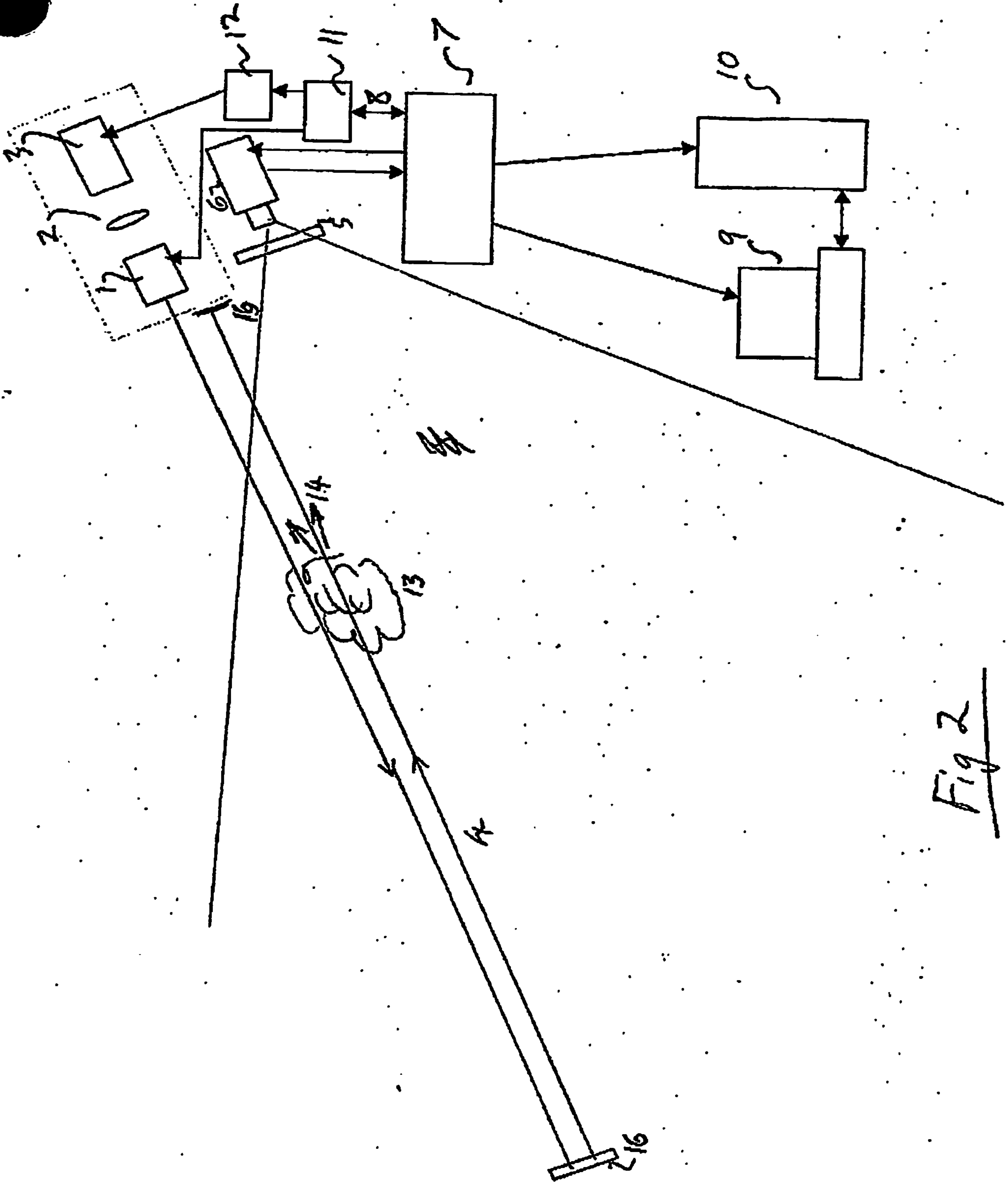

Fig 2